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Statistical Literacy: High School Students in Reading, Interpreting and Presenting Data

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Abstract. One of the foundations for high school students in statistics is to be able to read data; presents data in the form of tables and diagrams and its interpretation. The purpose of this study is to describe high school students' competencies in reading, interpreting and presenting data. Subjects were consisted of male and female students who had high levels of mathematical ability. Collecting data was done in form of task formulation which is analyzed by reducing, presenting and verifying data. Results showed that the students read the data based on explicit explanations on the diagram, such as explaining the points in the diagram as the relation between the x and y axis and determining the simple trend of a graph, including the maximum and minimum point. In interpreting and summarizing the data, both subjects pay attention to general data trends and use them to predict increases or decreases in data. The male estimates the value of the (n+1) of weight data by using the modulus of the data, while the females estimate the weighth by using the average. The male tend to do not consider the characteristics of the data, while the female more carefully consider the characteristics of data.

1. Introduction

Statistical literacy has become one of the important life skills Nowadays [1]. Being statistically literate is very important for every individual including students as informed citizens who can interpret the statistical messages in various contexts. Thus, statistical literacy, which is becoming a part of the school mathematics curriculum, plays a key role in preparing students to encounter the needs of society when they complete their elementary education [2]. The NCTM for example states, "A knowledge of statistics is necessary if students are to become intelligent consumers who can make critical and informed decisions" [3].

One of the way to improve statistical literacy mastery in students is to include statistical content in the national curriculum. However, based on preliminary research conducted by researchers related to statistical literacy of students, it was found that there are many students in high school and junior high school who have difficulty in reading, interpreting, or presenting data in the form of tables and diagrams. It indicates that the statistical literacy of students is low. A description of the students' with low statistical literacy can also be found in the study[4,5,6,7] which stated "children produced fewer idiosyncratic descriptions of data, possessed intuitive knowledge of center and spread and were constrained in analysis and interpretation by knowledge of data context".



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Taking into account the previous explanation, the purpose of this research is to describe the statistical literacy of high school students in reading, interpreting and presenting data as part of the basic ability that must be mastered by every student.

2. Theoretical Framework

There are several definitions and conceptualizations of statistical literacy found in the literature. Gal's statement clearly identifies a key element: statistical literacy involves the ability to read and interpret the data in tables and graphs published by government statistics associations [8].

Wallman indicated that statistical literacy includes both understanding and critically evaluating statistical messages that are necessary for daily life of individuals and for their decision making, as she highlighted both for the personal and societal needs [9]. Similarly, Gal's conceptualization also included the need for statistical literacy for active citizenship and pointed out that communication with statistics, and interpretation and judging of statistical claims are the key skills of statistically literate individuals [1]. Statistical literacy provides emancipations of citizens through enabling them not only to read data but also evaluate and communicate with statistical messages [10].

The statistical literacy can be understood by some to show minimum knowledge of basic concepts and statistical procedures [12,13]. The statistical literacy as Schield says, focuses on making decisions using statistic as proof. Statistical literacy involves two reading skills: understanding and interpretation [14].

The statistical literacy is an individual ability to understand [9,11,14,15,16]; interpret [15,17]; create table and graph [15,17,18]; the ability to make decisions using statistics as proof [14]. Statistical literacy is the ability of an individual ability to read (understand); analyze; interpret; and represent a data either in tabular or graphic form [19,20].

3. Method

The subject of the research was determined using purposive sampling technique. The subjects were chosen from the students of SMA Negeri 3 Sidoarjo which consisted of one male student and one female student who had high level of mathematical ability. Collecting data is done through task-based interviews. To obtain the validity of the data, the triangulation was used. The procedure of data analysis in this research refers to Miles & Huberman, with the following steps: (1) data reduction; (2) data exposure; and (3) conclusion and verification [21].

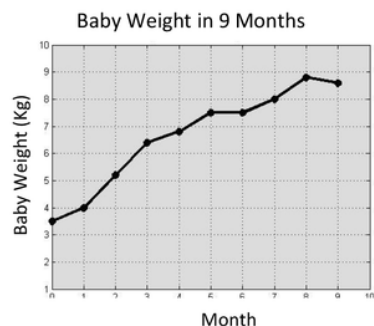
4. Results

The researcher gave two tasks to the subjects to measure and describe the students' statistical literacy. The first task related to the data presentation and the second task related to the ability to read and interpret data.

To describe the students' statistical literacy in terms of reading, interpreting and presenting data, the researcher gave the task of statistical literacy tests as follows:

1. Notice the line diagram below

- In what age does the baby weight decrease?
- What is the baby weight in 3 weeks age? Explain !
- What is the baby weight in 10 month age? Explain !



2. Consider the following data

- a) The "Literacy" store recorded monthly profits for a year (in million rupiahs) as follows

The Month	1	2	3	4	5	6	7	8	9	10	11	12
Profit	2.5	1.8	2.6	4.2	3.5	3.3	4.0	5.0	2.0	4.2	6.2	6.2

- b) The Number of students in a district based on school level in 2016 are:

Location	The number of students
Elementary School	175
Junior high school	600
Senior high school	225

- c) The Mathematics score of 40 students are

68	75	74	72	79	75	79	71	75	78
75	76	74	73	71	74	71	70	74	72
74	77	73	73	70	72	80	70	72	74
73	67	72	72	75	66	69	80	74	74

Based on given data, present the data in the most appropriate form! Give the reason!

Based on written answers and interviews conducted on the subject of research, and after validation of data, the results wasobtained as follows:

Male and female subjects stated that the provided diagrams were diagrams of infant weight measured from birth to 9 months of age. Subjects observed the relation of points presented in the diagram as the link between age and weight obtained from the relationship between the horizontal axis and the vertical axis. In case of increase and decrease of infant weight as well as the maximum, minimum or constant value obtained by the subject by comparing the trend graph and the value of the other. If the graph is seen decreasing, then it is concluded the weight of the baby decreased. In contrast, if the graph of the diagram increase, it is concluded that the baby's weight has increased. Baby's weight remains if the graph is constant.

The male and female objects at 3 weeks of age, infant weight of 3,875 kg obtained from infant weight at birth 3.5 kg plus average infant weight gain for 3 weeks, 0,375. Baby's weight beyond the data, was determined by adding preliminary data with an average increase or decrease stated by the female subject, while the male subject was hesitant in determining which value. Because according to the male subject, there are many factors that influence the data. Nevertheless, the baby's weight beyond the data was determined by the male subject by using a trend toward increasing or decreasing the baby's weight. The next data of baby's weight value can be determined by formula

$$x_{n+1} = x_n + p$$

where x_{n+1} is data (n+1), x_n show data n-th and p is lowest increase of baby's weight.

Furthermore, in presenting the data, if the subject was given data about store profits every month, the male and female subjects presented it in the form of line and bar chart on the grounds that readers will know the monthly profit store, whether there is an increase or decrease every month. Additional criteria stated by the female subject was to consider whether the characteristic data are discrete or continuous. If the data was continuous, then it was presented in the form of a line diagram and was presented in bar chart if it was discrete data.

Data on the number of students based on the level of school in a district by the male subject was presented in the form of a pie chart in the ground that readers will be easier noticing the number of students in each district. The female subject presented in the form of bar charts in order to compare the number of students for each grade of elementary school, junior high, and high school.

Data on the value of mathematics assignment from 40 students, by male or female subject presented in the form of frequency distribution table. This was seen by both subjects that it was more simple and effective and did not require many space in the presentation.

5. Discussion

Based on the explanation of subject data, there are several tendencies of students in reading, interpreting, and presenting data. In the context of reading data, the male and female subjects are able to read the title or topic of the graph, to give meaning to the units of the graph, to find the values or specific units, to find the maximum and minimum value in the graph. It can be inferred that the subject can look for information explicitly expressed in display, recognize graphical conventions, and establish a direct link between the original data and the display as stated in the reading data criterion of [22]. In the context of Aoyama and Stephens, the subjects can be said can read graphs, read simple trends from graph, read important parts of a graph [23].

The interpretation of the data in this context is the determination of a value that can not be explicitly determined directly from the reading data result, which Curcio stated as reading between the data and reading beyond the data [22]. Value can only be determined through a further process through interpolation or extrapolation as well as observations and inferences on general trends of data.

The female subject in estimating the value between the two data or beyond the data begins with considering on the link between the n -th and the $(n+1)$ data, comparing between the two to then decide whether there is an increase, a decrease or a constant. The general trend of the existing chart, serve as a guide in determining future value. In other words, in interpreting the data, the female subject is capable of performing global reading of trends in graphs as well as the criteria of statistical level D stated by Kimura [23]. In determining or interpreting data values, the female subject using the average value of increase or decrease data. If the average data tends to be a positive value, then it is concluded that there is an increase, otherwise if it is negative, then it is concluded there is a decrease. So to estimate value beyond the data, the female subject adds the value of the n -th data with the average increase or decrease to obtain the value of the n -th data $(n + 1)$.

It is somewhat different from the male subject. The male subject in identifying the increase or decrease in data, is tend to look at the data mode. If in the data, there is a lot of increase for each point of data, then the male subject concludes the data tends to increase with the assumption of normal condition. This means that there is no interference that causes the decline in data. In determining the value of the n -th data $(n + 1)$, the male subject defines it from summing the n -th data value with the least increase value of its data rate mode.

Based on these descriptions, it shows that the both subjects in estimating the increase or decrease in data, are guided by one of the data concentration values of mean, median, and mode. These values are used as a reference because the value of data centering gives an overview of how the characteristics of the data set are.

In the context of data presentation, both subjects are equally convinced that the presentation of a data is important because it will affect the understanding and information to be easily accessed by reader. Male and female subjects are able to present data in various forms including line diagrams, bar charts, histograms, pie charts, single data tables and frequency distribution tables. This means that both subjects are able to create tables, graphs and reports as proposed by Ben-Zvi and Garfield. They said that one of indicator that people have statistical literate if they are able to organize, compile and display data in tabular form, and able to work with different data representations [15]. Similarly, Schield states that "A core element for producers is the ability to create tables, graphs and reports that are unambiguous and comprehensible" [17].

Each of these forms of presentation is understood by both subjects having particularity in the presentation of the data. If a chart need to be emphasized on the ups and downs of a data quantity, then a line diagram and or bar chart are used. However, if the emphasized information is the quantity of data, then a pie chart is used. If a large number of random data (≥ 30) is obtained, then effective data presentation according to the male subject is the frequency distribution table. A more complex consideration exists on the female subject. Aside from the point of emphasis is on the purpose of the data presented, the subject also emphasizes the characteristics of the data. If the increase or decrease of a data to be presented in the form of continuous data, then the subject of women using the line chart, but if the data in question is discrete data, then the subject used the bar chart.

In the context above, both subjects meet the competency standard of high school graduates in the national curriculum related to the field of statistics: students are able to read data in the form of tables and bar charts, lines, pie charts, and ogive; able to present data in the form of tables and bar charts, lines, pie charts, and ogive and interpretation.

6. Conclusions

The results showed that the both subjects with high mathematical ability understand information directly from what is written explicitly the students read the data based on explicit explanations on the diagram, such as explaining the points in the diagram as the relation between the x and y axis and determining the simple trend of a graph, including the maximum and minimum point. In interpreting and summarizing the data, both subjects pay attention to general data trends and use them to predict increases or decreases in data. The males estimate the value of the (n+1) of weight data by using the modulus of the data, while the females estimate the weight by using the average. In presenting data, both subjects have ability to present data in various forms. However, the males tend to do not consider the characteristics of the data, while the female more carefully consider the characteristics of data and emphasize the purpose of information that be presented to the reader.

Suggestions given for future research, it is necessary to study the ability of statistical literacy of students for elementary school level until college. The description of the students' understanding will be used as a foundation in formulating competency standards for each level.

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